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13. ABSTRACT

The report

Describes a method for evaluation of earthmoving equipment performance and operational characteristics. It Identifies supporting tests, facilities, and equipment required. It Provides procedures for test planning, compatibility with related equipment, bulldozing earthmoving operations, scraper earthmoving operations, performance, salt fog, reliability, and endurance. Applicable to auger, angledozer, bulldozer, ditching machine, grader, and scraper. (U)

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14. KEY WORDS	LINK A		LINK B		LINK C	
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ANGLEDOZER AUGER, EARTH BULLDOZER DITCHING MACHINE EARTHMOVING EQUIPMENT GRADER SCRAPER						

U. S. ARMY TEST AND EVALUATION COMMAND
ENGINEERING TEST - SYSTEM TEST OPERATIONS PROCEDURES

AMSTE-RP-702-108
Test Operations Procedure 9-2-082 22 May 1972

EARTHMOVING EQUIPMENT

SECTION I
GENERAL

1. Purpose and Scope. This TOP describes test procedures for evaluating the operational and performance characteristics of earthmoving equipment. Equipment covered includes: auger, angledozer, bulldozer, ditching machine, grader and scraper. Testing of graders is covered in TOP/MTP 9-2-124. From the tests listed in Section II, the test director can select those that will satisfy the requirements for the particular test item and the particular test type (i.e., engineering test, initial production test, etc.). This document provides for simulated environmental testing but does not include service testing or environmental testing at climatic test sites.

2. Background. Military operations involving construction of highways, airfields, and bivouac areas require a capability to move large quantities of earth and vegetation in relatively short periods of time. Equipment

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designed and developed to perform this task consists of earth augers, bulldozers, (angledozers), ditching machines, graders and scrapers. Earth augers, used for drilling holes in the earth, may be mounted either on skids or trucks; angledozers and bulldozers, primarily used for brute strength removal of earth and vegetation, are mounted on either tracked or wheeled tractors or attached to combat tanks when the situation warrants it; ditching machines, for excavating and digging trenches, are mounted on crawler or wheeled vehicles; graders, used for smoothing or grading dirt areas, are special purpose vehicles with attached adjustable blades; scrapers, used for excavation and general earthmoving work, are hydraulically operated blades mounted on towed vehicles or as attachments to graders.

3. Equipment and Facilities. Equipment and facilities required are stated in the documents listed in Section II.

SECTION II
TEST PROCEDURES

4. Supporting Tests. Common Engineering MTP's/TOP's, Military Standards, tests defined in Section III, and other published documents to be considered in formulating an engineering test plan are as follows:

TEST SUBJECT TITLE	PUBLICATION NO.
a. Preoperational Inspection	2-2-502
b. Physical Characteristics	10-2-500
c. Safety Evaluation	10-2-508
d. Compatibility with Related Equipment (refer to para 6)	
e. Performance Tests (refer to para 9)	
(1) Auger, Earth	MIL-A-52470 para 4.5.2
(2) Angledozer and Bulldozer (refer to para 7)	MIL-A-17076C para 4.6.2 and 4.7
(3) Ditching Machine	MIL-D-52091C para 4.6.2
(4) Grader	9-2-124/MIL-G-52484, para 4.6.2
(5) Scraper (refer to para 8)	MIL-S-82082 para 4.5.2

TEST SUBJECT TITLE	PUBLICATION NO.
f. Environmental Tests	
(1) Temperature	AR 70-38
(2) Storage	AR 70-38
(3) Sunshine	4-2-826
(4) Rain	2-2-815
(5) Humidity	4-2-820
(6) Fungus	4-2-818
(7) Salt Fog (refer to para 10)	
(8) Electromagnetic Interference Characteristics (refer to para 9)	MIL-STD-461A Notice 4
g. Transportability (refer to para 9)	1-2-500
h. Human Factors Evaluation Noise Levels (refer to para 9)	10-2-505, 3-2-811
i. Reliability (refer to para 11)	AMCP 702-3 3-1-002
j. Endurance (refer to para 11)	2-2-507
k. Maintenance Evaluation	1-2-501, TECR 750-15

SECTION III
SUPPLEMENTARY INSTRUCTIONS

5. Test Planning. Engineering test planning requires the review of test guidance literature, establishment of test safety SOP's, determination of sequence of test phases, selection of sample sizes, etc. In selecting supporting tests previous testing must be taken into consideration. This can often lead to reducing the scope of the testing.

"High-risk" tests are conducted first, with precedence given to tests supporting the safety evaluation. Other tests are scheduled in the most economical sequence feasible. The test sequence of Section II constitutes one plan for scheduling according to this principle.

6. Compatibility with Related Equipment. Compatibility testing should be a continuing process throughout the entire test and to the extent practicable should be conducted concurrently with or as an adjunct to other scheduled operational tests. For example, any time the test vehicle becomes immobilized by terrain conditions or mechanical/electrical failures a record should be maintained of the method and equipment used to extricate and/or to tow or transport it and, when applicable, to start the engine. All such equipment that is available and methods not used in conjunction with other scheduled tests should be utilized. A coupling and servicing test is part of the compatibility evaluation. It consists of coupling the test item to, and servicing it with, all vehicles and equipment with which it is employed or serviced. The test is performed under realistic conditions of terrain. The test will determine:

a. Compatibility of components such as:

(1) Tow bars, towing pintles, towing hooks, shackles or clevises, and tow cables.

(2) Snatch blocks, slave cables,and connectors (electrohydraulic and pneumatic, if applicable).

(3) Service air brake connections, electrical lines, lighting connections, communications connections, and safety chains between test item and appropriate trailer(s).

b. Ease of coupling.

c. Servicing by fuel trucks, wreckers, and trucks that load the paving equipment.

d. The following is recorded for each operation:

(1) Vehicle used in conjunction with the test item.

(2) Nomenclature and, if available, the part or stock number of the components that were used.

(3) Interference, if any, with on-vehicle attachments and components.

(4) Ease of coupling, difficulties encountered.

(5) Difficulties, if any, experienced in servicing the test item.

7. Bulldozing Earthmoving Operations.

a. Objective. To determine bulldozing production rates during various engineer operations and to compare effective operating techniques and productivity with comparable Army equipment.

b. Method. Primary bulldozing is conducted in common soil with extensive time studies performed during straight bulldozing, slot dozing, T-pit, side cutting, bank dozing, and ditching. The type of dozing must be closely controlled so an adequate evaluation can be made. Explanation of the terms used in earthmoving operations are provided in appendix B. Bulldozing in soils classed as sand, gravel, and rock are conducted wherever these materials can be located. Bulldozing along stream banks is also evaluated and should include preparation of entry and exit ramps, obstruction clearing, bottom prepration, etc. A direct comparison with a standard Army dozer will be made when possible. Time studies should follow normally accepted commercial practices. Charts, forms and procedures are developed to suit the specific operation being studied. The following guidelines present the approach to these studies: A relatively open flat or gently sloped area is selected. An area may be cleared and prepared during the land clearing test.

(1) Under favorable digging conditions, it is assumed the load carried in front of the blade approaches the shape shown in figure 1. For bulldozers, the material will rise approximately 10% higher than the height of the blade. Using H as height of blade, W as width of blade, A as area (side view), L_1 as load carried in front of blade, and L_2 as load carried corrected to bank measure, the following formulas are derived to compute the capacity of the test item blade and standard bulldozer.

$$A = \frac{1.1H \times 2.2H}{2} = \frac{2.42H^2}{2} = 1.21H^2 \qquad (1)$$

$$L_1 = 1.21H^2 \times \frac{2W}{3} = \frac{2.42H^2W}{3} \qquad (2)$$

$$L_2 = 2.42H^2W \times 3/4 = .6H^2W \qquad (3)$$

Common earth swells 25% hence the 3/4 constant.
Loads are expressed in cubic yards.

H = Height of blade
W = Width of blade
2/3 W = Effective width

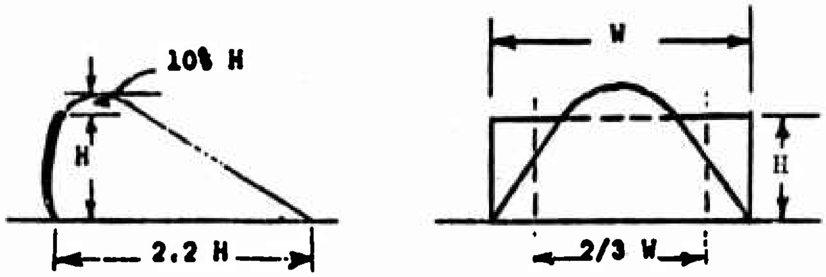

Figure 1. Load Carried in Front of Blade.

(2) The dozing cycle time may be computed as follows:

Fixed time + Variable time = Cycle time

Where:

Fixed time = shift time + cut time.
Shift time = approximately 0.330 minutes (two shifts).
Cut time = may be timed or may be assumed to be a part of the haul operation. In dozer cuts, the first 20 feet is assumed to fill the blade and any movement after that can be considered haul distance.

Variable time = travel forward + travel reverse.

$$\text{Travel forward} = \frac{\text{Haul distance}}{\text{Travel speed}}$$

$$\text{Travel reverse} = \frac{\text{Return travel distance}}{\text{Travel speed}}$$

(3) Bulldozer production rate can be estimated as follows:

$$\frac{\text{Blade capacity x 50-minute hour}}{\text{Cycle time}} = \text{Bank yards per hour} \qquad (4)$$

Where:

Blade capacity = the bank yards carried times efficiency.
50-minute hour = the productive working time in 1 hour is assumed to be 50 minutes.

Example:

Determine bulldozer production rate using the following assumptions:

Blade efficiency, 80%.
Computed bank measure capacity of blade, 6 yards.
Haul distance, 150 feet.
Common earth.
Travel speed forward, 1.5 mph.
reverse, 5.0 mph.
Cut time allowed as part of haul time.

Substitute in above formula number (4)

$$\frac{0.8 \times 6 \times 50}{0.330 + \frac{150 \times 60}{1.5 \times 5280} + \frac{150 \times 60}{5.0 \times 5280}} = 133 \text{ cubic yards per hour}$$

The factors noted in the formula above should be measured to authenticate or determine the proper numbers for the particular operation. The shift time, travel time, and haul distances should be measured. The volume of bank yards moved should be calculated by making geometric measurements of the cut. The soil should be identified and the moisture content determined. The soil density will be required for suitable evaluation. The in-place or bank density is quite different from loose density and the change must be known to properly compute production rates. The most productive dozing rates are obtained using the conventional method, i.e., with a tractor ballasted and using the bulldozer blade for earthmoving. Hence, this method should be the technique followed for the primary time study. Other possible dozing configurations include: Bulldozer blade fully raised, ejector gate forward; bulldozer blade fully raised, scraper bowl active; bulldozer blade and scraper bowl both active; and bulldozer blade only, vehicle not ballasted. Production rates are determined for each of these techniques.

(4) Land Clearing. Operations are conducted to determine ability of a tractor to perform land clearing functions, such as tree felling, brush clearing, stump removal, and boulder removal. A comparison Army standard bulldozer is also used. Evaluation of effectiveness is based on observation, and the most efficient techniques for clearing individual obstacles are developed.

(5) Grading. Grading operations are performed on virgin soil conditions with and without vegetation including trees, on fill areas, banks, and roadways The grading on a fill area should be satisfactory to a 6-inch vertical variation in 10 feet of horizontal travel. The techniques used in grading include all of the possible combinations that the test vehicle is capable of performing. The bulldozer blade should be used, moving forward or reverse, suspension locked or floating.

c. Data Required.

(1) Bulldozing production rate (yards per 50-minute hour) of the test tractor and standard Army bulldozer in various soils.

(2) Analysis of each type of soil worked, including moisture content, unit weight, and classification.

(3) Effectiveness of the bulldozer for performing grading operations.

(4) Notes on the most efficient work techniques and benefits and limitations of each.

d. Analytical Plan. The data obtained allows a direct comparison of the test tractor production rate with standard equipment. The most efficient operating techniques are verified for each type of earthmoving operation. Improvements of degradation in work output is determined by comparing production rate data obtained during previous testing if available.

8. Scraper Earthmoving Operations.

a. Objective. To determine earth moving production rates of scrapers performing normal load, haul and dump operations. The operating techniques and productivity are compared with equivalent Army equipment.

b. Method. Scraper operations are conducted over various soil conditions to measure maximum load conditions, develop the most suitable loading techniques, and determine production rates. Generally, scraper operation is conducted over undisturbed soil or soil in bank condition. The development of production rate data for scraper operation requires a study of specific phases of the scraper cycle and time studies of the entire scraper cycle as follows:

(1) Scraper Cycle. The scraper cycle includes: load, haul loaded, dump, turn, haul empty, and turn phases (figure 2). These phases are included in all operations as follows:

(a) Load. This is the pass made through the cut to force earth to enter and fill the bowl. This phase includes closing the apron, the raising to carrying height, and the shift of the proper gear position for hauling. The loading should always be made in the direction of the fill unless circumstances dictate otherwise.

(b) Haul Loaded. This is the travel period from the cut to the fill.

(c) Dump. This is the period of time in fill area for adjusting and dumping the load. Dumping should be in the direction of travel from the cut.

(d) Turn. The turn around to move back to the cut is made as soon as possible after dumping the load either in the fill or after leaving the fill depending on the condition that will permit the shortest time delay in returning to the cut.

(e) Haul Empty. This is the travel period from the fill area to the cut.

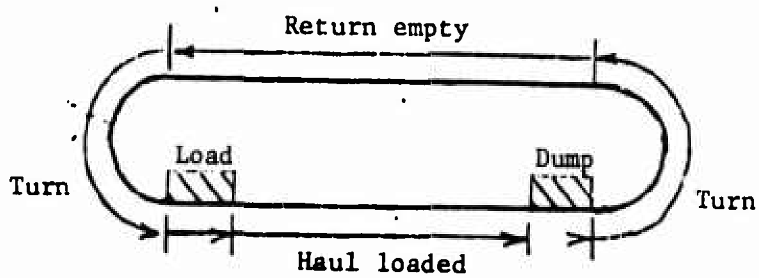

Figure 2. Scraper Cycle.

(2) Load Phase. The loading of the bowl is obtained by dropping the cutting edge below the surface the depth of the desired cut while moving forward in low gear position. The lower edge of the apron is raised sufficiently to allow the earth to enter the bowl and "boil" up into the bowl but low enough to retain the earth. Normally, this height of apron is slightly more than the depth of cut. The earlier part of this loading phase requires power or thrust to push the cutting edge

through the soil, but, as the load accumulates, it requires additional power to push the earth up through the load already acquired. This additional power or thrust requirement will result in lowered speed and the depth of cut may have to be reduced. The early loading will be obtained rather rapidly but, as the load of earth becomes greater, an increasingly greater amount of time is required to obtain the additional yards of earth. This relationship is known as load growth. Load growth curve should be obtained as a part of the production rate studies. Depending on the length of haul, the amount of time spent in obtaining the load and the load that is actually obtained should be varied to achieve the highest production rate. For extremely long haul distances additional time required to obtain several extra yards of earth may increase the production rate, but for short hauls the additional time might be better applied to the hauling effort. The load-growth curves should be obtained by following the procedure outlined in the SAE Handbook, Test Code - SAE J764. These loading operations should be conducted by both selfloading and push loading. The pushers used should include a standard bulldozer, another tractor, and other appropriate equipment. These results should be plotted on the same load growth curves. In particular, push loading should decrease the time required to obtain the last few yards to obtain a heaped load. Scraper loadings should be performed with several cutting edge arrangements. Basic data are obtained with the straight cutting edge. Other cutting blade arrangements may include the projecting center section or "stinger" and any other arrangements available for the universal engineer tractor. The loading data are presented on the same load growth curves..

(3) Haul Phase. Hauling both loaded and empty should be performed in the gear position that permits the shortest haul time compatible with the terrain and load being hauled. Haul distances should vary from 500 feet to 5000 feet to develop satisfactory production rate comparisons.

(4) Dump. The dump in the fill area is performed in two ways: by an even spread of earth with a lift of 2 to 6 inches or by expelling the earth as quickly as possible. In the former, the cutting edge is adjusted to the desired lift height, the apron opened progressively as the vehicle moves forward, and the cutting edge dropped slightly to maintain the same light weight;after the apron has been drawn away from the dirt, the ejector gate is moved forward at a rate that maintains a supply of dirt in front of the cutting edge until the gate is entirely forward and all dirt has fallen away. In the rapid dump, the vehicle maintains its carrying height and a speed of approximately 5 mph. The apron is opened as rapidly as possible and the ejector gate is moved forward quickly.

(5) Time Studies. Time studies of the scraper operation include the separate studies of the phases as noted above and the compilation of the data into a composite operation. There are fixed and variable time elements of the scraper cycle as follows:

(a) Fixed time includes the loading, shifting, dumping, and turning.

(b) Variable time includes haul loaded, haul empty and waiting. Waiting will not be considered although it can be important in an overall evaluation.

The production rate is computed as follows:

$$\frac{\text{Bank yards per load x 50-minute hour}}{\text{Round trip time}} = \text{Bank yards per hour} \quad (5)$$

Where:

Bank yards per load = corrected yards of earth in scraper. (As the earth is removed from the cut, it swells so that the amount in the bowl is not the same. The swell factor must be determined and the yards of earth in the scraper corrected to bank yards.)

50-minute hour = productive working time in 1 hour.
Round trip time = fixed time plus variable time.

Example: Assume -

Scraper capacity (heaped), 18 yards.
Swell factor, 20%.
Haul distance - loaded, 1000 feet
empty, 1100 feet.
Average travel speed, 7 mph.
Fixed time (load, shift, dump, turn), 2.6 min.

Variable time:

Haul loaded, 1000 feet, $\frac{1000 \times 60}{7 \times 5280}$ = 1.62 minutes

Haul empty, 1100 feet, $\frac{1100 \times 60}{7 \times 5280}$ = 1.78 minutes

$$\frac{18 \times .80 \times 50}{2.6 + 1.62 + 1.78} = 12.0 \text{ Bank yards per load} \times 8.3 \text{ trips per hour}$$
$$= 99.6 \text{ Bank yards per hour.}$$

Scraper operations are conducted on common earths including loam and clay to develop the basic data and operating techniques. Operations are also conducted on sand, gravel, blasted rock, along shore lines and under other conditions that permit scraper operations. Time studies are conducted on as many of these soils as conditions permit. Operations in sand should include the capability of loading, quantity of load, action of sand on moving parts, and ejection capabilities. In addition to these functions, the denting and jamming, particularly around the ejector gate, should be noted when operating in gravel. When operating in blasted rock the loading techniques and damage should be carefully observed, including effects of large boulders.

(6) Grading. Grading operations are performed on virgin soil conditions with and without vegetation including trees, on fill areas, banks, and roadways. The grading on a fill area should be satisfactory to a 6-inch vertical variation in 10 feet of horizontl travel. The techniques used in grading include all of the possible combinations that the test vehicle is capable of performing. The scraper cutting edge should be used, moving forward or reverse, suspension locked or floating.

(7) Hauling. Production rates and suitability of the test vehicle as a hauler are noted. Time studies are conducted with the test item and a comparable Army standard dump truck. Both units are loaded with a front end loader and the earth is hauled over a rough road bed, simulating a typical haul road. A 1-mile-long haul road is suggested for comparison purposes. Average times to load, haul, dump, and return are obtained. The complete cycle time and the average volume of material hauled are used to determine the production rate. The soils used for loading should include earth, sand, gravel, and rock. Observe the effect of loading the materials by side loading and top loading the size of load by each method, the damage that occurs from the various materials, and the special techniques, limitations, or restrictions that will minimize damage or jamming.

c. Data Required.

(1) Scraping production rate (yards per 50-minute hour) for the test scraper and comparable standard scraper in earth, sand, gravel, and rocky soils.

(2) Volume of earth hauled (cubic yards) per scraping cycle.

(3) Elapsed time (minutes) for each phase of the scraping cycle.

(4) Vertical variation (inch) in 10 feet of horizontal travel during grading operations.

(5) Hauling production rate (yards per hour) for the test tractor and a standard Army dump truck.

(6) Notes on the most efficient work techniques and benefits and limitations of each.

(7) Effectiveness of the scraper for performing grading operations.

d. Analytical Plan. The data obtained allows a direct comparison of the test scraper production rate with standard equipment. The most efficient operating techniques are verified for each type of earthmoving operation. Improvements of degradation in work output is determined by comparing production rate data obtained during previous testing if available. Load growth curves are developed for the scraper operation.

9. Performance Tests. The tests described in the military specifications listed in Section II, paragraph 4e are those normally required for IP and IC tests; most, however, would apply to ET's. Some of those specifications call for electromagnetic interference tests, noise level tests, lifting and tiedown tests, environmental tests, and others that are covered also in other subtests listed in Section II. In such cases the other subtests should be used as guidance. In selecting the tests to be accomplished, the test director should be guided by the MN documents and TC's applicable to the item to be tested and to the TECOM test directive.

10. Salt-Fog Tests. Items covered in this document are generally too large for the exposure chambers normally available for this test. These items may be exposed to salt-laden atmosphere at actual shore sites such as Fort Story, Va. or other available seashore locations. Exposure of the test item to salt-laden atmosphere in lieu of environmental chamber testing as per MIL-STD-810 would involve operation of the equipment in the shallow water near the shore environment, exposing it to salt water and salt spray. After the equipment has been adequately exposed it should be statically stored without washing for 240 hours. On the fifth day the test item is examined and exposed again to salt water and salt spray, followed by the remainder of the 240-hour test. At the conclusion the test, item is examined for corrosion and operated.

11. Reliability and Endurance. Every ET and IPT of a vehicle will contain either separate reliability and endurance subtests, or a combined subtest called Reliability and Endurance. For earthmoving equipment, the combined test title will normally be used.

b. Requirements for endurance, durability, and reliability are established by one of the following: Materiel Need (MN), Test Directive, Technical Characteristics (TC), AMC Technical Committee Minutes (AMCTCM"s), Research and Engineering Purchase Descriptions (REPD's) or other specifications. In the absence of such criteria, recourse is made to data generated in previous testing of similar items; the test item should not be less reliable than the system being replaced. These documents serve as sources of criteria for test plans.

c. The reliability and endurance subtest is a test which involves repeated mission accomplishments in order to subject the item to extensive wear under typical field conditions. It may also involve certain mileage over test courses. (see TOP/MTP 2-2-507.) This test is the predominant means by which data are accumulated not only for the reliability subtest, but also for the maintenance evaluation, evaluation of riding qualities and human factors, fuel and lubrication requirements, handling qualities, utility of cargo areas, and overall performance.

d. Reliability is defined as the probability that an item will perform its intended function for a specified time under specified conditions. For vehicles, reliability is expressed in terms of one or the other of the following two attributes:

(1) Mean-Time Between-Failures (MTBF). This is often expressed for vehicles as mean-miles-between-failures (MMBF). It is used when an operational profile is not well defined. To use MTBF one must assume a certain distribution of failures: for vehicles, failures are assumed to be distributed as an exponential random variable. MTBF is best used for items that operate continuously under constant conditions, but can be used for vehicles when the testing encompasses a fair representation of all of the conditions the vehicle may experience in roughly the right proportions. The MTFB or MMBF is a byproduct of the maintenance evaluation subtest data analysis.

(2) Mission Reliability. This is the probability of achieving a successful mission of specified duration under specific use conditions. A typical mission reliability statement is: a reliability of 0.90 at 90% confidence level of completing an 8-hour mission during the first 2000 hours of operation. A mission may simply be a certain distance to be travelled,or it may also include certain additional actions, such as clearing a certain area or moving a certain amount of earth. Sometimes reliability requirements are stated for two or more operational profiles, or different phases of a mission may be assigned different reliability requirements.

e. Reliability is a specialized, mathematical subject in which the guidance, the state-of-the-art, and the policies are continually being reappriased and altered. Thus, test planning and data analysis require participation by specialists who are constantly keeping abreast of this field. The test engineer should always consult with reliability experts as early as possible when planning a test and analyzing data. The wording of statements in the report should also be checked with these specialists because statistical terms have specific definitions. Subtle changes in wording can alter the meaning tremendously. There will occasionally, however, be some test projects of a repetitive nature where durabiltiy and reliability determinations have been reduced to easily applied formulas, tables, graphs, and instructions, but these are the exceptions.

f. A durability test (TOP 1-2-502) is concerned with the probability that the test item will perform satisfactorily to its service life. It will probably never be conducted with earthmoving equipment because of the large sample size and extensive test duration that are required. Further guidance on reliability, endurance and durability testing of vehicles is contained in TOP/MTP 2-1-001.

Recommended changes to this publication should be forwarded to Commanding General, U. S. Army Test and Evaluation Command, ATTN: AMSTE-ME, Aberdeen Proving Ground, Md 21005. Technical information may be obtained from the preparing activity: Commanding Officer, Aberdeen Proving Ground, ATTN: STEAP-MT-M, Aberdeen Proving Ground, Md 21005. Additional copies are available from the Defense Documentation Center, Cameron Station, Alexandria, Va 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A
REFERENCES

1. AR 70-38, "Research, Development, Test, and Evaluation of Materiel for Extreme Climatic Conditions."

2. AMC Supplement 1 to AR 11-26, "Value Engineering."

3. MIL-STD-271D, "Nondestructive Testing Requirements for Metals."

4. MIL-STD-461A, "Electromagnetic Interference Characteristics, Requirements for Equipment," including notices 1 through 4.

5. MIL-STD-462, "Electromagnetic Interference Characteristics, Measurement of," including notices 1 through 3.

6. MIL-STD-781B, "Reliability Tests: Exponential Distribution," including change 1.

7. MIL-STD-810B, "Environmental Test Methods," including notices 1 through 4.

8. MIL-A-17076C, "Angledozers and Bulldozers, Earthmoving: Cable and Hydraulic Operated, for Crawler Tractors."

9. MIL-A-52470, "Auger, Earth, Truck-Mounted, 36-inch Diameter Hole, 60-Foot Maximum Depth."

10. MIL-D-52091C, "Ditching Machine: Diesel-Engine-Driven; Wheel-Mounted; Ladder," including amendment 1.

11. MIL-G-52484, "Graders, Road, Motorized, Airdroppable and Helicopter-Transportable, Diesel-Engine-Driven."

12. MIL-S-82082, "Scraper, Earthmoving, Towed; Hydraulically Operated, 14-Cubic Yard Struck Capacity, 6-Line Hydraulic System."

13. American Society for Testing and Materials (ASTM), "E18-Rockwell Hardness Test."

14. Society of Automotive Engineers, Inc., "1971 SAE Handbook."

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APPENDIX B
DEFINITIONS

I. SOIL TERMINOLOGY

a. In-Place or Bank Yards. This is the earth volume in its natural location before handling. It is the earth in the borrow pit, cut or bank and is the volume upon which payment is usually based, thus the expression "pay yards."

b. Loose Yards. This is the volume after it is removed from its natural location. It has not been compacted.

c. Compacted Yards. This is the earth volume after it has been properly compacted in the embankment or fill. Generally, this is a smaller volume than the equivalent bank yards.

d. Swell. Earth tends to increase in volume due to loosening up after it has been removed from its natural state. This increase in volume is known as "swell." Common earth tends to swell approximately 25%.

e. Shrinkage. Earth placed in the fill and compacted usually has a lesser volume than it occupied in its natural state in the cut, embankment, or borrow pit. This decrease in volume is known as shrinkage. An exception to this is broken rock, which will occupy a greater volume than in its natural state. Swell and shrinkage may be expressed as a percentage of the volume of its natural bank yards or undisturbed state. Shrinkage of common earth, for example, after compaction is approximately 20%.

f. Spoil. Material that has been removed from an excavation or cut and either piled for future reference or hauled away to be dumped or used.

II. BULLDOZING TERMINOLOGY

a. Straight Bulldozing, Rectangular Pit (fig 3). This pit is cut in a forward and reverse cycle. The cut is made in the long direction of a 100- by 50-foot pit. Method of cutting is to make one cut to a depth of 2 feet, then to move over approximately a blade width and make another cut and so on across the width of the pit. Production for a 2-foot cut depth is now established. Now the operator goes back and cuts the ridges down 4 feet leaving 2-foot ridges and a 4-foot depth production is established. The 2-foot ridges are now cut 2 feet. The spoil may be dozed and spread back for loose soil production times. A comparable standard dozer should work along with the test tractor to give a direct work capacity comparison; it could do half of the pit while the test tractor does the other half.

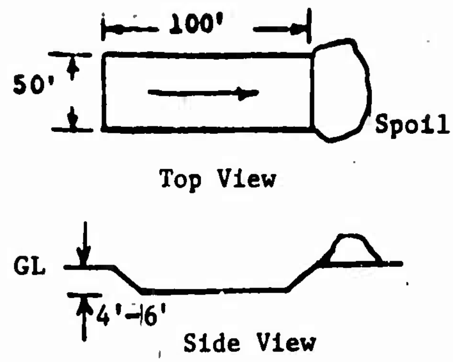

Figure 3. Rectangular Pit.

b. T-Pit (fig. 4). This is a simulated gun position to test the tractor in slot type dozing in both in-place and loose material. The pit is cut by making a slot 42 feet long and 4 to 6 feet deep with the spoil pile at one end. The stem of the tee is approximately 20 feet long and cut sloping to the floor of the cross. The material from the stem is pushed into the cross and then pushed onto the spoil pile.

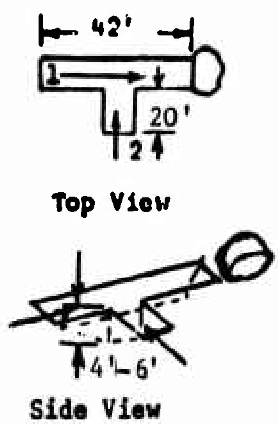

Figure 4. T-Pit.

c. Slot Dozing (fig.5). This operation is to check engine and running gear cooling in a confined space and whether the running gear loads up or wears badly due to spillage onto the tracks. The slot will be 4 to 6 feet deep, 100 feet long, and a blade width wide.

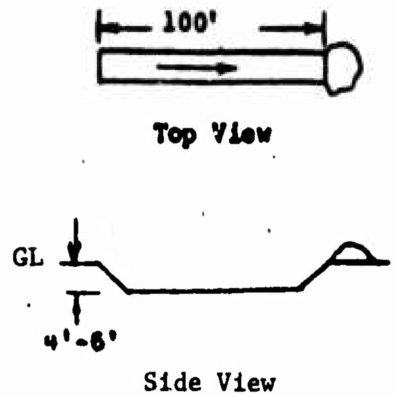

Figure 5. Slot Dozing.

d. Side Cutting. This will subject the vehicle to side torsional loads and evaluate steering characteristics and track slip. A simulated road can be cut into the side of a hill, or a plateau cut into a hill.

e. Bank Dozing. Bank dozing is performed to evaluate steer characteristics and crowding action of the test tractor against a bank. Tilt dozer operation may enhance the capability of performing this activity. An assessment is made of the effects of soil falling into the running gear. Cuts are made along the vertical face of an embankment.

f. Ditching. This operation is to impose strain and torsional loads on running gear and track. Tilt dozer operation is required to perform this activity. The method is to cut a 6-foot-deep V-ditch 100 to 200 feet long, with a side slope of 3:1 and 2:1.

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